AFRL-ML-TY-TP-2005-4529

RESPONDING TO COMPOSITE FIRES: FIRST RESPONDER TRAINING MODULE

Jennifer Kiel, Douglas Dierdorf
Applied Research Associates
P.O. Box 40128
Tyndall AFB, FL 32403

D. McBride, T. Harmon
University of Maryland
Maryland Fire & Rescue Institute
College Park MD 20742

S. Yarlagadda, C.H. Newton, J.W. Gillespie, Jr.
Center for Composite Materials
University of Delaware
Newark DE 19716

Interim Technical Paper, May 2005

Air Force Research Laboratory
Materials and Manufacturing Directorate
Airbase Technologies Division
139 Barnes Drive, Suite 2
Tyndall AFB, FL 32403-5323

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
31-MAY-2005	Interim Technical Paper	01-OCT-2003 -- 31-MAY-2005

4. TITLE AND SUBTITLE

Responding to Composite Fires: First Responder Training Module

5a. CONTRACT NUMBER

FA8651-04-C-0303

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

62102F

6. AUTHOR(S)

Jennifer Kiel, Douglas Dierdorf, D. McBride, T. Harmon, S. Yarlagadda, C. H. Newton, and J. W. Gillespie Jr.

5d. PROJECT NUMBER

4915

5e. TASK NUMBER

D2

5f. WORK UNIT NUMBER

4915D24C

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Applied Research Associates, Inc.
P.O. Box 40128
Tyndall AFB, FL 32403

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory
Materials and Manufacturing Directorate
Tyndall AFB, FL 32403-5323
Air Force Materials Command
United States Air Force

10. SPONSOR/MONITOR'S ACRONYM(S)

AFRL/MLQD

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

AFRL-ML-TY-TP-2005-4529

12. DISTRIBUTION/AVAILABILITY STATEMENT

Distribution Statement A: Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

Ref AFRL/MLQ Public Affairs Case # 05-015.

14. ABSTRACT

The important and growing use of composite materials in civilian and military applications, such as in aircraft, motor vehicles, mass transit and marine industry creates new and often unrecognized hazards for firefighters and the general public. Researchers in the US and overseas have identified that: composites are combustible materials, ignition can occur in as little as four seconds in a Cone Calorimeter, heat release rates exceed those for kiln dried pine lumber, and composites produce "deep-seated" fires. Firefighting research has not yet addressed the impact of these new materials, which in many cases replace noncombustible metals. The Air Force and NASA have committed major efforts over the past 30 years to understanding the post fire hazards related to dispersed fibers and combustion products. This research resulted in the recent publication of First Responder PPE and operating requirements as part of the Hazardous Aerospace Materials Mishap Emergency Response (HAMMER) integrated product team. A training module is under development that incorporates these requirements and other relevant materials for first responders. The purpose of this training module is to provide civilian and military firefighters and first responders with the methodologies they need to assure rapid and safe extinguishment of composite materials fires.

15. SUBJECT TERMS

composite materials, graphite composites, aircraft, mass transit

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Virgil Carr
U	U	U	UU	10	19b. TELEPHONE NUMBER *(Include area code)*

Reset

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

ABSTRACT

The important and growing use of composite materials in civilian and military applications, such as in aircraft, motor vehicles, mass transit and marine industry creates new and often unrecognized hazards for firefighters and the general public. Researchers in the US and overseas have identified that: composites are combustible materials, ignition can occur in as little as four seconds in a Cone Calorimeter, heat release rates exceed those for kiln dried pine lumber and composites produce “deep-seated” fires. Firefighting research has not yet addressed the impact of these new materials, which in many cases replace noncombustible metals. The Air Force and NASA have committed major efforts over the past 30 years to understanding the post fire hazards related to dispersed fibers and combustion products. This research resulted in the recent publication of First Responder PPE and operating requirements as part of the Hazardous Aerospace Materials Mishap Emergency Response (HAMMER) integrated product team. A training module is under development that incorporates these requirements and other relevant materials for first responders. The purpose of this training module is to provide civilian and military firefighters and first responders with the methodologies they need to assure rapid and safe extinguishment of composite material fires.

1. BACKGROUND

The increased risk of composite deep-seated fires and potential health issues for firefighters resulted in a growing concern identified by the Air Force Research Laboratory's Fire Research Group. Advanced composite materials are showing up in huge numbers in both Air Force and civilian new aircraft, increasing strength, decreasing weight and increasing hazard risk. Aircraft mishaps involving advanced composite materials present unique safety, environmental and potential health hazards.

In October of 2002 the first Composite Fire Safety Initiative meeting was held in Washington, D. C. to discuss the increased use of composites in Air Force, DoD, and civilian technologies because of the emerging fire safety issues related to these materials. The program is dedicated to developing an understanding of composite combustion processes and to providing civilian and military firefighters with the education, methodologies and technologies needed to safely extinguish composite material fires. A key concern of the initiative involves providing firefighters with proper support and training to effectively combat these hazards.

In FY04 the Composite Fire Safety Initiative was sponsored by the Strengthening the Mid-Atlantic Region for Tomorrow (SMART) congressional caucus. Under this initiative, scientists and engineers from the Air Force Research laboratory's Materials and Manufacturing Directorate Fire Research Group (AFRL/MLQD) began working cooperatively with experts from the University of Delaware, the University of Maryland, and the firefighting community. The Composite Material Fire Safety training program is a direct deliverable of this initiative aimed at improving the safety and effectiveness of military and civilian firefighters.

The result is a three day fire fighting training course taught in six sections that introduces the basics of composite materials, reviews hazardous material response procedures, provides information on composite materials burns and firefighting tactics to be utilized in combating composite material fires, and covers techniques for overhauling the hazard after the fire. Students will take a practical exam on the last day.

The USAF publishes a Technical Order (TO), TO 00-105E-9 that is currently available to military and civilian firefighters and the general public[1]. This valuable resource contains a major section (Chapter 3) on Mishap Composite Awareness. A main deliverable of the Composite Fire Safety Course is communication of the pertinent information contained in the TO relating to combating composite material fires. Efforts to create a lighter, faster, more efficient aircraft, motor vehicles and mass transit led to the increased use of composite materials. For example, 24% of the airframe for the next generation fighter, the F/A-22, is composite material, creating a new level of need for the information in this TO to be taught at the beginning of a firefighter's career. In the civil aviation scenario,

---

1. The Technical Order is publicly available online at

http://www.robins.af.mil/logistics/LGEDA/documents/to00-105E-9.htm

the need is equally pressing as the new Airbus 380 and 350, as well as the Boeing 7E7 have targeted at least 50% of the aircraft to be composite materials.

Composite materials begin to degrade structurally approximately ten seconds after exposed to flame. Thus, fire department response to a fire on or near an aircraft must be in seconds to prevent irreversible damage. TO 00-105E-9 provides guidance on fire response to aircraft containing composite materials. Training the fire properties of composites to determine proper fire response will reduce injuries and mission time, increasing the possibility of saving lives without additional risk to the firefighter, while decreasing both the damage to aircraft and property loss.

The courses stresses handling composite materials incidents with caution, using proper personal protective equipment, proper decontamination of responders, and is expected to reduce injuries and deaths related to complications firefighters encounter when responding to composite material fires. The course provides the student with a better understanding of composite materials, including how they are constructed, used, and where firefighters can expect to encounter them. Finally, students review firefighting tactics and learn the agents applications that work best when combating fires involving composites. More than 10,000 DoD firefighters, first respondents and hundreds of thousands of civilian firefighters are expected to receive and benefit from the program.

The completed program was demonstrated in February 2005 and delivered April 2005 to the DoD's **Louis F. Garland Fire Academy** at Goodfellow AFB, San Angelo, Texas. It will also be available through the Maryland Fire and Rescue Institute.

2. COURSE OUTLINE

This Training Course is designed to provide civilian, military firefighters, as well as first responders with the education, and methodologies they need to assure rapid and safe extinguishment of composite material fires. This course will present the importance of handling Composite Material Incidents with Caution. The importance of the proper use of Personal Protective Equipment and proper decontamination of responders will be stressed and explained.

It is very important that Emergency Responders realize that composites are everywhere in our world today, anywhere strength is required, and reduced weight is a necessity. This course will illustrate that even though composites are prevalent in the aviation industry, they are present everywhere in today's environment. The outline of the course is as follows:

Session 1 Introduction to Composite Materials

- Objective: The student shall have a better understanding on how composite materials are constructed, used, and where the firefighter should expect to encounter prevalent composite materials.
- ***Session 1 Overview:***
    - Introduction & Administrative Duties

        - Course Overview
    - Introduction to Composite Materials,
        - Definition
        - Uses, and Locations
        - History
        - Locations
        - Prevalent Materials

- ***Session 1 Enabling Objectives (EO):***

    1. EO-1-1 List the reasons that Composite Materials are utilized in today's manufacturing world
    2. EO-1-2 List the locations a firefighter should suspect that Composites are located.
    3. EO-1-3 List the most prevalent materials used in manufacturing.
    4. EO-1-4 Identify the definition of a composite material

Session 2 Hazardous Material Response and Mitigation Refresher

- Objective: The student shall review procedures learned in Hazardous Material Courses, how composite material releases compare, and the proper decontamination procedures to be utilized following every incident involving composite materials.

- ***Session 2 Overview:***

    - Hazardous Material Refresher
        - Recognition & Identification / Information
        - Personal Protective Equipment
        - Detection
        - Risk Assessment
        - Decontamination
        - Decontamination Procedures

- ***Session 2 Enabling Objectives:***

    1. EO-2-1 List the proper processes utilized to safely mitigate a Hazardous Material Incident.
    2. EO-2-2 Identify the Health Effects that Hazardous Materials present.
    3. EO-2-3 Identify the difference between exposure and contamination
    4. EO-2-4 Identify the routes that a hazardous material may enter the human body

5. EO-2-5 List the proper terminology utilized when describing a hazardous material
6. EO-2-6 List the steps for proper decontamination of anyone that may be contaminated at an Incident scene

Session 3 Composite Material Incident Hazards and Life Safety

- Objective: The student shall understand what happens when composite materials burn and aircraft systems are subjected to failure and a catastrophic fire situation both in testing as well as actual emergency situations
- ***Session 3 Overview:***
  - Composite Material Dangers Faced by Firefighting Crews
  - Incident Case Studies
    - F-117 Crash
    - UH-60 Helicopter
    - Boat Storage Facility Fire
  - Composite Burn Tests – Mojave Test Center
- ***Session 3 Enabling Objectives:***
  1. EO 3-1 Identify the dangers posed by Composite Materials after an incident.
  2. EO 3-2 Identify the areas of concern, based on actual incident case studies.
  3. EO 3-3 List the burn observations observed during the test burns
  4. EO 3-4 Identify the key points found in each incidents conclusion

Session 4 Composite Material Fire Behavior, Strategies and Tactics

- Objective: The student shall have an understanding of Composite Material Fire Behavior, and the Firefighting tactics to be utilized in combating fires involving composite materials.
- ***Session 4 Overview:***
  - Composite Material Fire Behavior
  - Firefighting Tactics
  - Mishap Risk Control Guidelines
- ***Session 4 Enabling Objectives:***
  1. EO-4-1 Identify the behavior that is be expected when composite materials are subjected to, and become involved in fire.

2. EO-4-2 Identify the heat generated, and by-products emitted by the burning composite materials.
3. EO-4-3 List the Strategies and Tactics that should be utilized when combating a fire involving composite materials.
4. EO-4-4 Identify the proper Personal Protective Equipment that should be utilized in each tactic involved in the mitigation of the incident.
5. EO-4-5 List the Mishap Risk Control Guidelines for Composite Material Incident response.

Session 5 Proper Extinguishing Agents and Fixants for Composite Materials

- Objective: The student shall understand which agents and applications work best for combating fires involving composite materials. The student shall also understand the proper steps to take in overhauling after fire involving composite materials, and the use, and type of fixants to be utilized during overhaul.
- ***Session 5 Overview:***
  - Firefighting Agents & Application
  - Composite Material Fire Overhaul
  - Composite Material Fixants & applications
- ***Session 5 Enabling Objectives:***
  1. EO-5-1 Identify the preferred agents utilized in combating composite material fires.
  2. EO-5-2 Identify the proper agent application utilized in combating composite material fires.
  3. EO-5-3 List the steps utilized in overhaul in combating composite material fires.
  4. EO-5-4 Identify the fixants utilized during overhaul of a composite material incident.
  5. EO-5-5 Identify the proper application methods of fixants on composite materials.

Session 6 Practical Evolutions and Written Examination

- Objective: The student shall observe and fully understand all information received during the course by participating in an actual practical evolution.
- ***Session 6 Overview:***
  - Simulated Composite Material Test Burn
    - Preparation

        - Test Burn
        - Overhaul
        - Remediation
    - Course Review
    - Written Examination

- ***Session 6 Enabling Objectives:***

    1. EO-6-1 Demonstrate the proper tactics utilized to mitigate a composite material incident.
    2. EO-6-2 Demonstrate proficiency in the proper selection, donning, and use of Personal Protective Equipment utilized in mitigating a composite material incident.
    3. EO-6-3 Demonstrate proficiency in the operation of the proper respiratory protection utilized in the mitigation of a composite material incident.
    4. EO-6-4 Demonstrate the proper tactics utilized in handling a hazardous material

COURSE STATUS

One of the main goals of the Fire Safety Composite Initiative is to provide military firefighters with the education, methodologies, and technologies needed to safety respond to composite material fires. Over the last year AFRL, the University of Delaware, and the University of Maryland have constructed a training course, based on TO 00-105E-9, entitled "Composite Fire Safety" to be delivered to the DoD Fire Academy. The Dover AFB Fire Department agreed to host the pilot version of the three day course from Feb 7 to Feb 9, 2005 and provide constructive feedback for the purpose of fine tuning the course before finalizing it.

The course took two full days to deliver, including a hazardous material practice response. The exam for future classes will be given in the morning of the third day. The participants included 24 firefighters from Dover AFB Fire Department, the Delaware Air National Guard, and Air Force Reserves.

The participants were extremely responsive to the training. A recommendation to consider is marketing or combining this training with a simulated hazmat response exercise so that firefighters can accomplish their 8-hour HAZWOPER refresher in conjunction with this program. The firefighters at Dover suggested and accomplished this during the pilot course.

Feedback from the pilot version is currently being incorporated into the course, along with feedback from representatives of AFCESA (Air Force Civil Engineering Support Agency). After completion, the first official course delivery is planned in April 2005 at the DoD Fire Academy at Goodfellow AFB, Texas. Steps are being taken to obtain

course accreditation and implement the course into the regular training curriculum for First Responders and Emergency Personnel.

CONCLUSIONS

A three day fire fighting training course has been developed to educate and train First Responders and Emergency Personnel on handling Composite Materials incidents and fires. It taught in six sections that introduces the basics of composite materials, reviews hazardous material response procedures, provides information on composite materials burns and firefighting tactics to be utilized in combating composite material fires, and covers techniques for overhauling the hazard after the fire. Students will take a practical exam on the last day. Pilot delivery of the course at Dover AFB was received with enthusiasm and provided feedback for modifications to the course. First official delivery is planned at the DoD Fire Academy in April 2005, followed by steps to obtain accreditation and implementation into the regular curriculum.

ACKNOWLEDGEMENTS

The authors are grateful to the SMART Team for providing the support to fund this initiative, to AFCESA, FAA, NIST, AFRL HQ, The Louis F. Garland Fire Academy, and the Dover AFB Fire Department for continued support and constructive feedback during the course development. This research was sponsored by the Department of Air Force, AFRL-MLQD and was accomplished under the Composite Fire Safety Initiative, agreement number FA8651-04-C-0303.